APPLICATION OF WET ELECTROSTATIC PRECIPITATION TECHNOLOGY IN THE UTILITY INDUSTRY FOR PM2.5 CONTROL

Wayne Buckley
Dr. Isaac Ray
Croll-Reynolds Clean Air Technologies
PO Box 668, Westfield, NJ 07091
E-mail: wbuckley@croll.com; Telephone: (908)-232-4200; Fax: 908-232-2146

Summary

Wet electrostatic precipitation technology is currently being used in industrial applications to control acid mists, sub-micron particulate, mercury, metals and dioxins/furans as the final polishing device within an multi-pollutant air pollution control system. For more than 50 years, wet electrostatic precipitators (wet ESPs) have been standard technology in sulfuric acid plants to abate H2SO4 mist, a sub-micron droplet. Unfortunately, wet electrostatic precipitation is a relatively unknown technology to most utilities because air regulations up to recently have not required high levels of control of sub-micron particulate.

Wet ESPs are capable of removing sub-micron droplets, acid mists, metals and mercury particles as small as 0.01 micron in size with up to 99.9% removal efficiency. Near zero opacity can be achieved. When integrated with upstream control equipment, such as a SCR, dry ESP and scrubber, multiple pollutants can be removed with the wet ESP acting as the final polishing device.

Smoke plume from a stack is the clearest sign of the presence of sub-micron particles in a gas stream. Due to refraction of sunlight, 0.5-micron particles are the most visible. Additionally, the surface area of the smallest particles in a flue gas is greater than the surface area of larger particles. One gram of 0.1-micron particles has 10 times the surface area as a gram of 1.0-micron particles (60 m^2 vs 6.0 m^2). Toxic vapors however, condense uniformly on the surface area of all particles. That is why the capture of a gram of 0.1-micron ash particles is 10 times more effective at removing toxic pollutants than the capture of a gram of 1.0-micron ash particles.

Dry ESPs have been used successfully for many years in industrial and utility applications for coarse and fine particulate removal. Dry ESPs can achieve 99+ percent efficiency for particles 1 micron to 10 micron in size. However, dry ESPs a) cannot remove toxic gases and vapors that are in a vapor state at 400°F, b) cannot efficiently collect very small fly ash particles, c) cannot handle moist or sticky particulate that would stick to the collection surface, d) require a lot of real estate for multiple fields due to re-entrainment of particulate and e)rely on mechanical collection methods to clean the plates, which require maintenance and periodic shutdowns. Therefore, dry ESPs may not be the best practicable control device to meet the proposed PM2.5 standard, or as a final mist eliminator for acid gas mist on FGD systems in order to reduce opacity levels.

Wet ESPs operate in the same three-step process as dry ESPs—charging, collecting and finally cleaning of the particles. However, cleaning of the collecting electrode is performed by washing the collection surface with liquid, rather than mechanically rapping the collection plates. While the cleaning mechanism would not be thought to have any impact upon performance, it significantly affects the nature of the particles that can be captured, the performance efficiencies that can be achieved and the design parameters and operating maintenance of the equipment. Simply stated, wet ESP technology is significantly different than dry ESP technology.

Because wet ESPs operate in a wet environment in order to wash the collection surface, they can handle a wider variety of pollutants and gas conditions than dry ESPs. Wet ESPs find their greatest use in applications where gas streams fall into one or more of the following categories:

- The gas in question has a high moisture content;
- The gas stream includes sticky particulate;

- The collection of sub-micron particulate is required;
- The gas stream has acid droplets or H_2SO_4
- The temperature of the gas stream is below the dew point.

Because wet ESPs continually wet the collection surface area and create a slurry that flows down the collecting wall to a recycle tank, the collecting walls never build up a layer of particulate cake. Consequently, there is no deterioration of the electrical field due to resistivity, and power levels within a wet ESP can be dramatically higher than in a dry ESP.

Wet operation also prevents re-entrainment. The captured particulate flows down the collection wall in suspension to a recycle tank for treatment and never gets re-entrained into the flue gas. This reduces the need for multiple fields, as in a dry ESP where additional fields must be added to capture re-entrained particles from the previous field.

Wet ESPs can be configured either as tubular precipitators with vertical gas flow or as plate precipitators with horizontal gas flow (Figure 1). For a utility application, tubular wet ESPs would be appropriate as a mist eliminator above a FGD scrubber, while the plate type could be employed at the back end of a dry ESP train for final polishing of the gas. In general, tubular precipitators are more efficient than the plate type and take up less space due to simple geometry.

Like dry ESPs, wet ESPs can be modular. Each field is limited in size to the power of the available transformer. The largest transformers available today are 70,000 V @ 2500 mA of installed electrical power. Depending on the specific application (large air flow or heavy inlet loading), multiple sections can be arranged together, either in series or in parallel, to achieve the required efficiencies. Where a dry ESP train already exists, the last field can be retrofitted into a wet field for final polishing of the flue gas.

A pilot demonstration of wet ESP technology is being performed at First Energy's Bruce Mansfield Station where a 10,000 cfm slip stream is connected to a tubular, up-flow wet ESP to test for SO_3 mist and $PM_{2.5}$ control. The plant needs to reduce opacity it to 20%. Preliminary testing to date has demonstrated the successful application of wet ESP technology in meeting the plant's goals with up to 96% removal efficiency achieved and apparent near zero opacity.